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Improvements to address issues leading to cancellation of the July 2014 plutonium experiment

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Abstract

Overview: A Pu shot scheduled for July 17 on the Z machine at SNL was cancelled this past summer. The LiF windows on the Pu targets were cracked during assembly because of configuration changes. Sandia management concluded that continuing with this experiment would present an unacceptable level of risk to the facility and possibly to the workers. In this report, we document the events that occurred which led to this decision and also present some lessons learned and plans and procedures put in place to reduce the likelihood of another such occurrence. The changes and this memorandum reflect the thinking of subject matter experts at both LANL and SNL. These changes represent significant improvements in both communication protocols and quality of the hardware assemblies.

ACKNOWLEDGMENTS

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NOMENCLATURE

LANL	Los Alamos National Laboratory
DOE	Department of Energy
SNL	Sandia National Laboratories

1. CAUSES OF THE LIF WINDOW CRACKING

1.1. Target redesign to adjust for larger sample diameters

1.1.1. Description of the original configuration and procedures

The target for this experiment consists of a thin cylindrical metal target of Pu that is glued between a Lithium Fluoride (LiF) window and an aluminum drive plate that is part of the electrical load system for Z. When the machine is fired, current flows through this aluminum panel, producing a large magnetic field and subsequent hydrodynamic pressure wave in the panel. This pressure wave is transferred to the metal target, producing the conditions of interest for the program.

Sandia's safety basis for transportation, handling and shot execution requires two seals between the target and the environment. The outer seal is a vacuum tight container that comprises the hardware set. The hardware set, which includes the panel and probe body, is assembled at Sandia (without the Pu target) and checked for leaks. The hardware is then disassembled and sent to LANL. The metal target is glued to a cylindrical LiF window using angstrom bond epoxy, a low viscosity adhesive suitable for thin bonds. This sample/window stack is glued to the bottom of the panel counterbore, again using angstrom bond. A secondary bead of stycast epoxy, a very high-viscosity adhesive used to make hermetic seals, is applied between the LiF window and the counterbore wall. The bead of stycast and the LiF window make up the inner seal. Angstrom bond and stycast are commonly used in applications with radiological and radioactive materials. The limited life of organic materials in a radiological environment is known; there is a 21 day period between when the samples are glued and when the experiment is conducted due to concerns regarding degradation of the Pu surface. After the target is glued into place, the probe body is secured to the panel with an o-ring face seal and the target "assembly" is complete. A picture of the target assembly is shown below in Figure 1. LANL conducts radiological surveys at each step to verify the seals. In the past these surveys were the only post-assembly verification of the seals. When completed, the target is packaged and shipped to Sandia. Upon arrival the target is removed from its packaging, surveyed to ensure there is no external contamination, and then released to SNL personnel to be aligned and loaded into the machine.

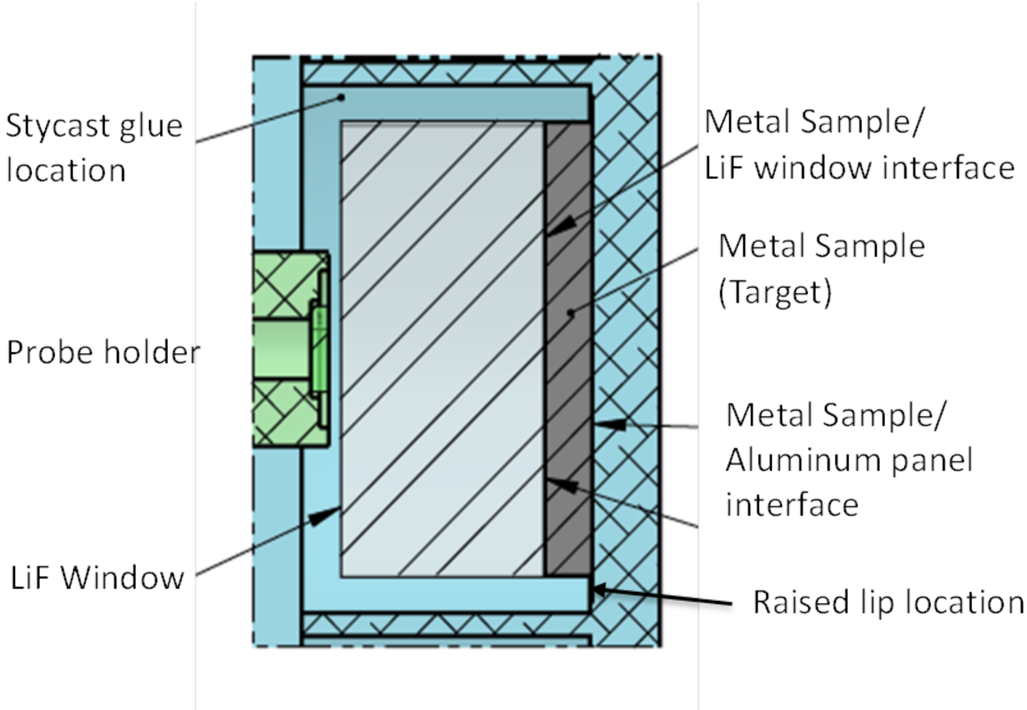

Figure 1. Target assembly drawing showing region that contains the metal disk.

1.1.2. Configuration of the July 2014 experiment.

For this particular experiment, a few changes occurred that produced some unforeseen results that compromised the perceived integrity of the target. First, the panel was modified slightly by increasing the diameter of the counterbore by .020" (0.5 mm). This was done for two reasons. To meet particular experimental objectives the diameter of the sample was slightly increased, resulting in a sample/window stack where the sample and window were the same diameter. The increased sample diameter prompted a corresponding increase in the counterbore diameter to accommodate the fact that the bottom inside corner of the counterbore has a small radius (caused by the radius of the lathe tool) and is thus not absolutely flat. There was concern that without an increase in the diameter of the counterbore the larger diameter sample might "ride up" this radius, thereby compromising the mechanical integrity of the glue bond.

1.2. Communication issues regarding target redesign

This change was documented in the drawings sent to LANL from Sandia, but was not specifically highlighted. There was an inherent assumption made by the experimentalists and designers at Sandia that LANL used centering jigs to ensure concentricity of the counterbore and the sample/window stack. This assumption was incorrect and thus the significance of changing the diameter of the sample and counterbore was not recognized. In addition, LANL personnel did not realize anything was significantly different until they assembled the target. The procedure LANL used previously had relied on the fact that the window diameter was slightly larger than the sample diameter; this precluded the sample from "riding up" the radius at the bottom of the counterbore, even if the window edge came into contact with the counterbore wall.

1.3. Impact of redesign on target assembly—the crack

During assembly the sample/window stack migrated toward the counterbore wall, resulting in the sample "riding up" the radius at the bottom of the counterbore, as shown in Figure 2. With the sample not sitting flat on the counterbore face the pressure used to hold the window into place cracked the window. The implications of these cracks in the windows were not fully appreciated right away. The staff at LANL understood these were not expected and could cause problems, so they took several steps to determine the implications for the experiment and for preventing contamination that could result from the cracks.

First, they took pictures and documented the positions of the cracks. They also performed radiological surveys of the targets after gluing and determined that there was no contamination on any of the exposed surfaces. They then attached the probe body to the panel with the o-ring face seal. LANL shipped the targets after communicating with Sandia. Sandia agreed to the shipment, so that the schedule could be maintained in the event that a full evaluation of the risks to safety and data quality indicated that the experiment could proceed without acceptable risk. On the Sandia end, it was quickly determined that the cracks were in a position that did not necessarily compromise the data quality. This is shown in figure 2 below, where one can see that the position of the cracks were away from the center of the window. This made it feasible to obtain the required measurements and proceed with the shot. Sandia then proceeded to do an evaluation of the environmental and safety risks associated with this unforeseen problem of the cracked windows.

2. EVALUATION OF RISK BASED ON CHANGES IN TARGET INTEGRITY—IMPACT OF IMPERFECT SEALS

An issue that became apparent after much discussion was the reliance Sandia had placed on reducing overall risk to personnel and the machine through defense in depth. For example, the target was assumed to be doubly sealed, relying on both the vacuum seal of the container and the initial stycast seal of the target. The crack in the window cast doubt as to the integrity of the stycast seal. As a result there was much discussion on what level of additional risk was added if that seal was now compromised. It was determined after some discussions with LANL that the stycast seal might also be compromised. Verification of the second seal for the assembly consisted of radiological surveys but not exposure to vacuum environments as would occur during the pump-down before the experiment. Thus, it was thought prudent to check again the first stycast seal by opening up the assembly and performing radiological surveys of the exposed surfaces. If the surfaces showed evidence that the seal no longer held integrity, the shot would be cancelled.

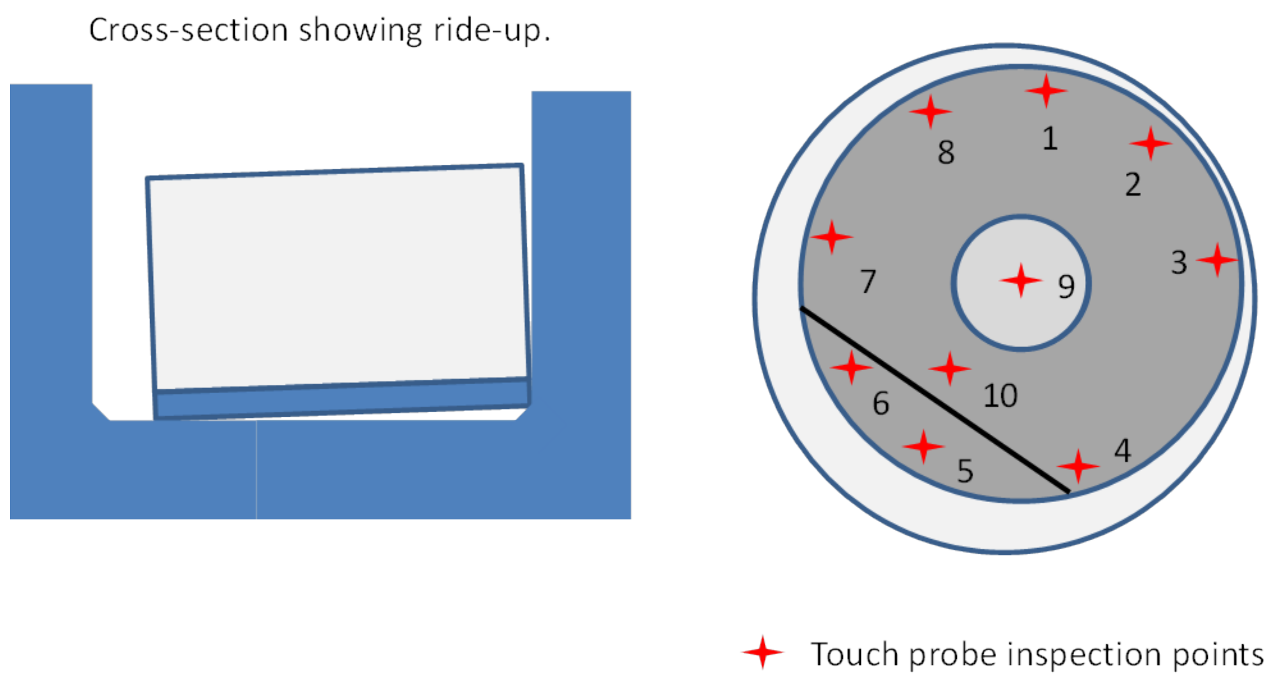

Figure 2. Drawing of position of target sandwich in the cylindrical sleeve and the position of the crack.

2.1. Determination of possible issue to Z in case of small leak

The reason for this determination was a concern that if the vacuum integrity of the assembly was compromised, contamination could be pulled from the assembly into the vacuum chamber and possibly vented into the Z high bay through the exhaust of the roughing pump. Though the amount of material that could possibly be lost was estimated to be very small, it was not possible without going through a much more sophisticated analysis to determine how small. An added element of risk involved the lifetime of these stycast seals. Previous experience suggested that these seals decayed over time, so waiting a long time before making a decision was not deemed an appropriate option. Thus, the most prudent action was believed to be opening up the target assembly and just checking. However, we quickly discovered that such a procedure was not as simple as we believed.

2.2. Determination of limitation in procedures if target did leak and rejection of target

When evaluating what work was required to open up the assembly to check the primary seal, we realized that this was a procedure we never specifically planned for in our loading and unloading operations. In addition, we also realized that procedures made an implicit assumption that we were unlikely to measure any contamination, so we had not defined a procedure to deal with the situation if we did measure some contamination. Though it was previously determined that in such an instance a plan would be developed in consultation with rad waste personnel, this was deemed inadequate for the immediate purpose. Sandia management then made the decision that because of the short time scale before a decision needed to be made and because we were not prepared to carry out the procedure of checking the assembly without reevaluating our procedure, we should not accept the target and return it to LANL. Thus, the shot was effectively cancelled at that time.

3. PATH FORWARD

3.1. Configuration management

To go forward from this event, several changes are being implemented into the steps and procedures we are using to carry out these Pu experiments on Z. First, Sandia will now document in the target configuration memos all specific changes with respect to previous assemblies that might affect the assembly of the target. By calling out these changes explicitly, LANL can more readily evaluate whether the changes in design have any implication for the assembly procedures of the target. LANL will review the changes and the LANL MST-16 group leader or designee will sign-off on the configuration in an email to the 1640 senior manager. If there are concerns, the issue can be communicated to Sandia and appropriate measures taken.

3.2. Seal configuration and verification improvements

Another set of improvements focuses on the assembly and testing of the target. When assembling the target and gluing it into place, LANL will use a centering tool to keep the sample/window stack in the center of the counterbore. In addition, they will use a sufficient amount of Angstrom bond glue to fully encapsulate the metal target. This will fill the counterbore around the LiF window and enhance the seal produced by the stycast. An illustration of the new target configuration is shown in figure 3. LANL will also pull a vacuum on the target to ensure the stycast glue fills the area around the target sandwich uniformly. This should not only prevent the problem that occurred in this instance, it should also produce a more solid stycast seal. LANL and SNL assemblers and radiation protection experts agreed that these changes significantly improve the quality of the inner seal. Lastly, the vacuum integrity of the container will be checked by LANL after it is assembled using an overpressure test that includes measuring a He leak rate. This will ensure the integrity of the o-ring seal after final assembly. Finally, the procedure used at Sandia to unpack the sample will be modified to include a procedure for addressing a target that has become contaminated. This procedure will describe how to decontaminate the target and/or how to safely replace the target into a container that can be transported to a local storage area before shipping back to LANL. These changes, we believe, will improve not only the integrity of the targets themselves, but also our ability to understand and evaluate any changes or issues that may arise. As a result of these changes, both LANL and Sandia believe we have more knowledge of the state of these targets and can thereby make better determinations on whether we have done an adequate job of mitigating the risks associated with these experiments.

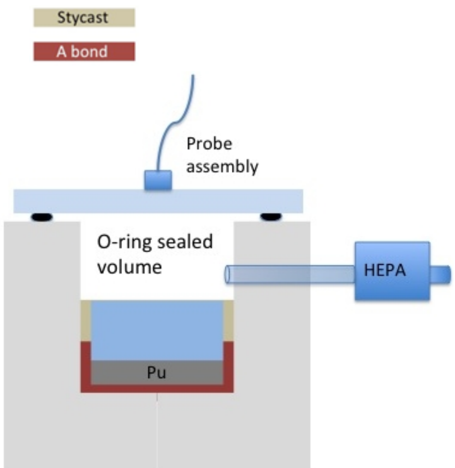

Figure 3. Illustration of the second (O-ring) seal. The seal is leak tested by over-pressurizing the volume inside the cell with He while in a vacuum chamber.

4. REFERENCES

1.

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